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High-flux composite PTMSP membranes with long-term stable characteristics at elevated temperatures and pressures

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Modern development of gas, chemical, and petrochemical industry encounters a challenging problem related to the effective removal of carbon dioxide from gaseous environments at elevated pressures (40 – 150 bar). Membrane gas absorption—desorption (MGA/D) offers an alternative approach to the existing technology. The MGD recovery of CO_2 at high temperatures (100^oC) and pressures (40 bar) places specific demands on both chemical and thermal stability of the membranes as well as on their barrier characteristics (no transfer of a liquid phase, a solution of an absorbent).

Taking into account the above reasoning , it seems promising to use defect-free composite membranes with a nonporous selective layer based on highly permeable and heat-resistant polymer glasses such as poly[1-(trimethylsilyl)-1-propyne] (PTMSP).

In the works by Nguyen et. al. [1], membrane CO_2 gas absorption was studied for the PTMSP composite membranes based on the PP hollow fibers with a permeance of 3-6 m^3(STP)* (m^2*h*bar)$^{-1}$. The membranes showed their stable performance at 60^oC and in the contact with aqueous solutions of alkanolamines. However, these membranes fail to resist high temperatures (100℃) and pressures (up to 40 bar).

Therefore, in our work, a metal-ceramic microfilter was used as a support. The high-performance composite membrane with a defect-free selective layer was prepared by the solution coating method. As follows from Table 1, initially high permeance of the composite membranes is seen to decrease after their annealing at 100℃ and achieves an invariable level after the 150-h exposure. In this case, gas permeance decreases by a factor of 20 but initial selectivity is preserved.

Table 1. Gas transport characteristics of initial and annealed composite membrane at 25^oC.

Membrane:	Initial composite membrane	Duration of annealing at 100^oC, h		
Gas permeance at 25^oC, m^3(STP)* (m^2*h*bar)$^{-1}$		150	250	350
N_2	7,7	0,4	0,4	0,4
CO_2	36,3	1,6	1,6	1,6
$\alpha(CO_2/N_2)$	4,7	4,0	4,0	4,0

Upon desorption of CO_2 from the saturated 50% aqueous solution of N-methyldiethanolamine at 40 bar and 100℃, no liquid phase flow through the aged membranes (annealing at 150℃) takes place. Therefore, the as-prepared composite membranes can be used for the regeneration of chemical absorbents of CO_2 at elevated temperatures and pressures and this approach makes it possible to solve two following problems: (i) to provide

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high CO_2 flow and (ii) to ensure high barrier characteristics with respect to a liquid absorbent (the absence of hydrodynamic flow of an absorbent through the membrane).

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